Modeling Optimal Bay Scallop Habitat in Nantucket, MA
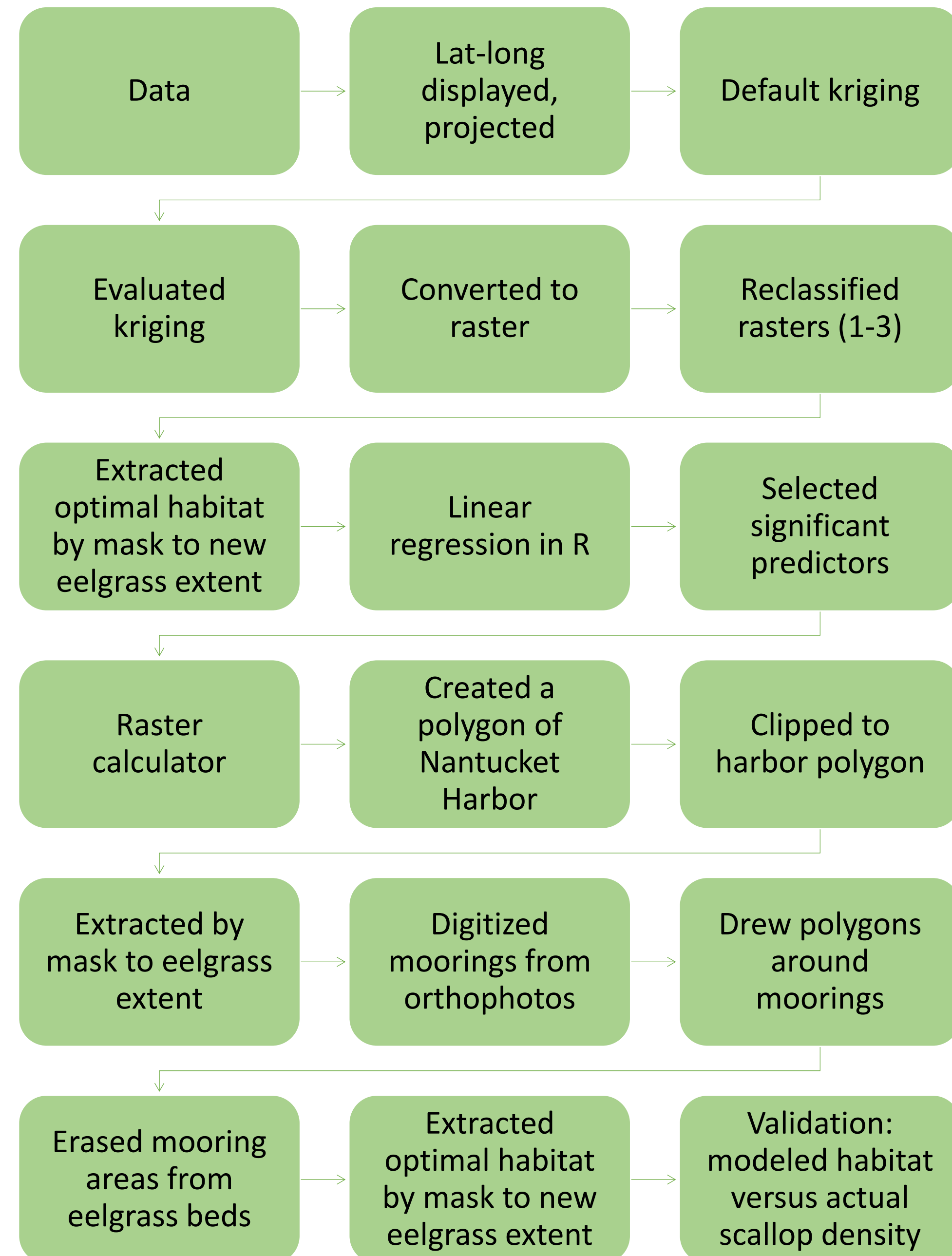
Kimberly Hack, Steven Kuffel, Andrew McCandless, Whitney McClees
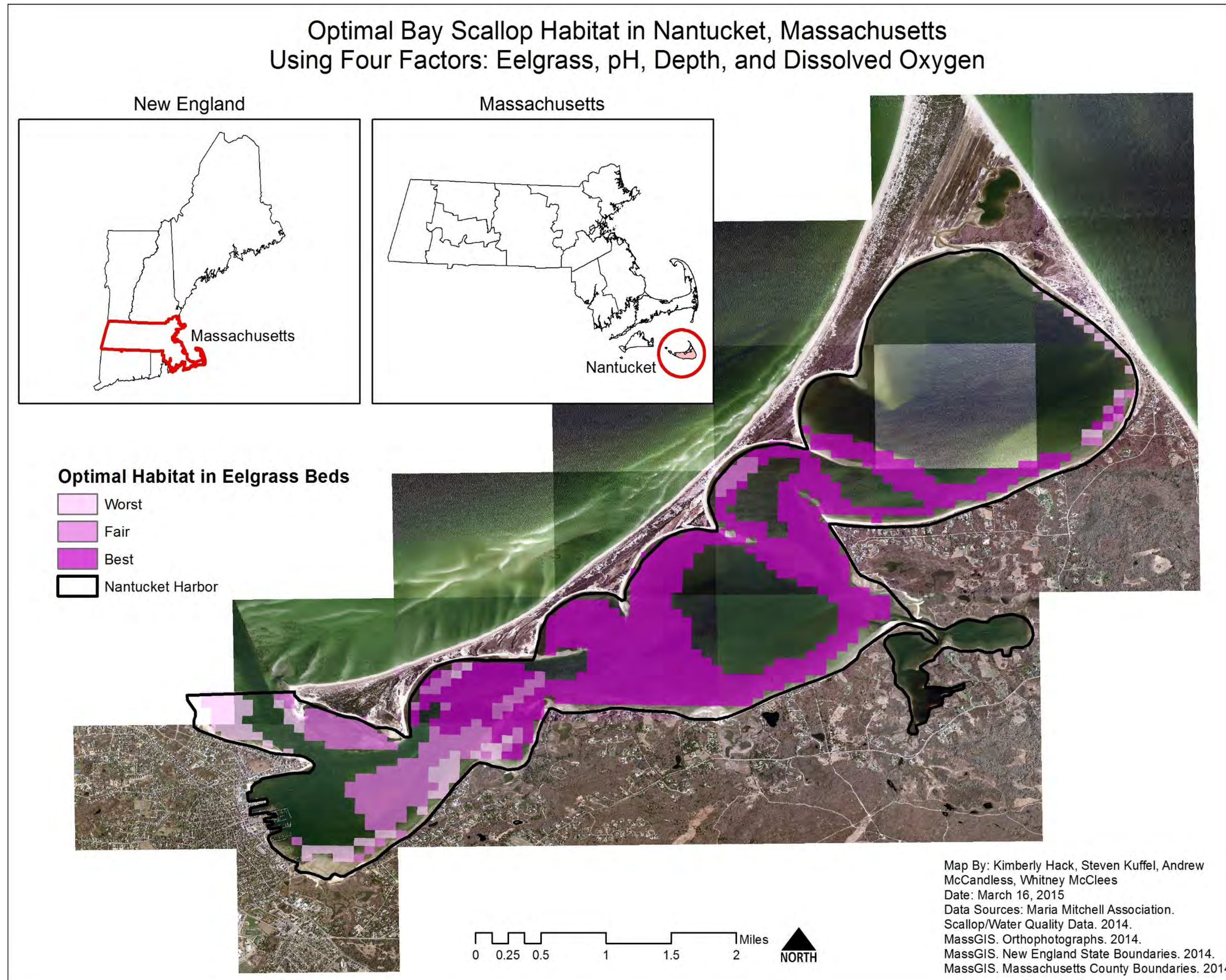
Introduction

This study focused on a population of bay scallops, *Argopecten irradians irridians*, that inhabit Nantucket Harbor, Massachusetts. Scallop harvesting is a substantial economic industry in the harbor, but populations have been declining over time as a result of many factors such as overharvesting and habitat decline[1]. Bay scallops are extremely sensitive to natural as well as anthropogenic disturbances and require good water quality along with habitat, such as eelgrass beds, that allows for shelter, foraging, and reproductive success[1].

Methods/Analyses Performed

Data → Lat-long displayed, projected → Default kriging

Evaluated kriging → Converted to raster → Reclassified rasters (1-3)

Extracted optimal habitat by mask to new eelgrass extent → Linear regression in R → Selected significant predictors

Raster calculator → Created a polygon of Nantucket Harbor → Clipped to harbor polygon

Extracted by mask to eelgrass extent → Digitized moorings from orthophotos → Drew polygons around moorings

Erased mooring areas from eelgrass beds → Extracted optimal habitat by mask to new eelgrass extent → Validation: modeled habitat versus actual scallop density

Final Habitat Suitability

Optimal Bay Scallop Habitat in Nantucket, Massachusetts
Using Four Factors: Eelgrass, pH, Depth, and Dissolved Oxygen

New England

Massachusetts

Nantucket

Optimal Habitat in Eelgrass Beds
- Worst
- Fair
- Best
- Nantucket Harbor

Map By: Kimberly Hack, Steven Kuffel, Andrew McCandless, Whitney McClees
Date: March 16, 2015
Data Sources: Maria Mitchell Association. Scallop/Water Quality Data. 2014.
MassGIS. Orthophotographs. 2014.
MassGIS. New England State Boundaries. 2014.
MassGIS. Massachusetts County Boundaries. 2014.

0 0.25 0.5 1 1.5 2 Miles   NORTH

Raster Calculator

pH

pH * 0.319

Depth

Depth* 0.297

Dissolved Oxygen (%)

DO * 0.384

Bay Scallop Quantity

Optimal Habitat

Based on linear regression of scallop abundance (dependent variable) based on environmental variables. $P = 0.0108$, $R^2 = 0.2131$

Validation

Optimal Habitat in Eelgrass Beds
High : 2.681
Low : 1.384

Scallop Density Exceed Median Threshold
- 0 - 0.214255741
- 0.214255741 - 0.344248326
- 0.344248326 - 0.423117027
- 0.423117027 - 0.470968003
- 0.470968003 - 0.5
- 0.5 - 0.529031997
- 0.529031997 - 0.576882973
- 0.576882973 - 0.655751675
- 0.655751675 - 0.785744259
- 0.785744259 - 1
Nantucket Harbor

In order to validate the model, we compared the habitat layer to a prediction map of where scallop density exceeds the median number of scallops. The red areas on the map indicate areas with scallop density much higher than the median. Areas that have higher scallop density than the median would indicate better habitat.

For the most part, the best habitat (white) matched up well with areas of high scallop density with the exception of the areas at the mouth of the harbor that have high predicted scallop density but poor predicted habitat (black and gray overlapping red areas to the left of the map).

There are several potential reasons for the disagreement at the mouth of the harbor: the scallop prediction model might not be entirely accurate based on the limited number of data points used; the water quality variables near the mouth of the harbor are not as ideal as other, more protected areas of the harbor; there might be a higher number of scallops at the mouth because it is difficult for commercial and recreational fishermen to access the mouth of the harbor and not a useful economic location.

Why the Bay Scallop?

- Multi-million dollar scallop fishery
  - Nantucket bay scallops shipped worldwide
  - Commercially and recreationally harvested
- Cultural significance
  - Important fishery for hundreds of years
  - Provides a connection to the island's maritime past
- Ecological functioning
  - Filter-feeders
  - Important food source for birds

Figure 1. Nantucket Island. Nantucket Land Council, Inc. 2014.

Figure 2. Basket of freshly caught Nantucket Bay Scallops. Cary Hazelgrove Photography. 2009.

Results/Conclusions

Limiting the best habitat to eelgrass beds was an extremely important step as eelgrass is vital to the scallop life cycle and subsequent survival. Thus, eelgrass beds became the fourth parameter for determining the best habitat for bay scallops in Nantucket Harbor.

The location of the best habitat for bay scallops based on pH, depth, and dissolved oxygen (%) and location of eelgrass beds is concentrated in the middle of the harbor (dark pink). The less desirable habitat areas are concentrated at the mouth of the harbor as well as at the head of the harbor (lighter pinks).
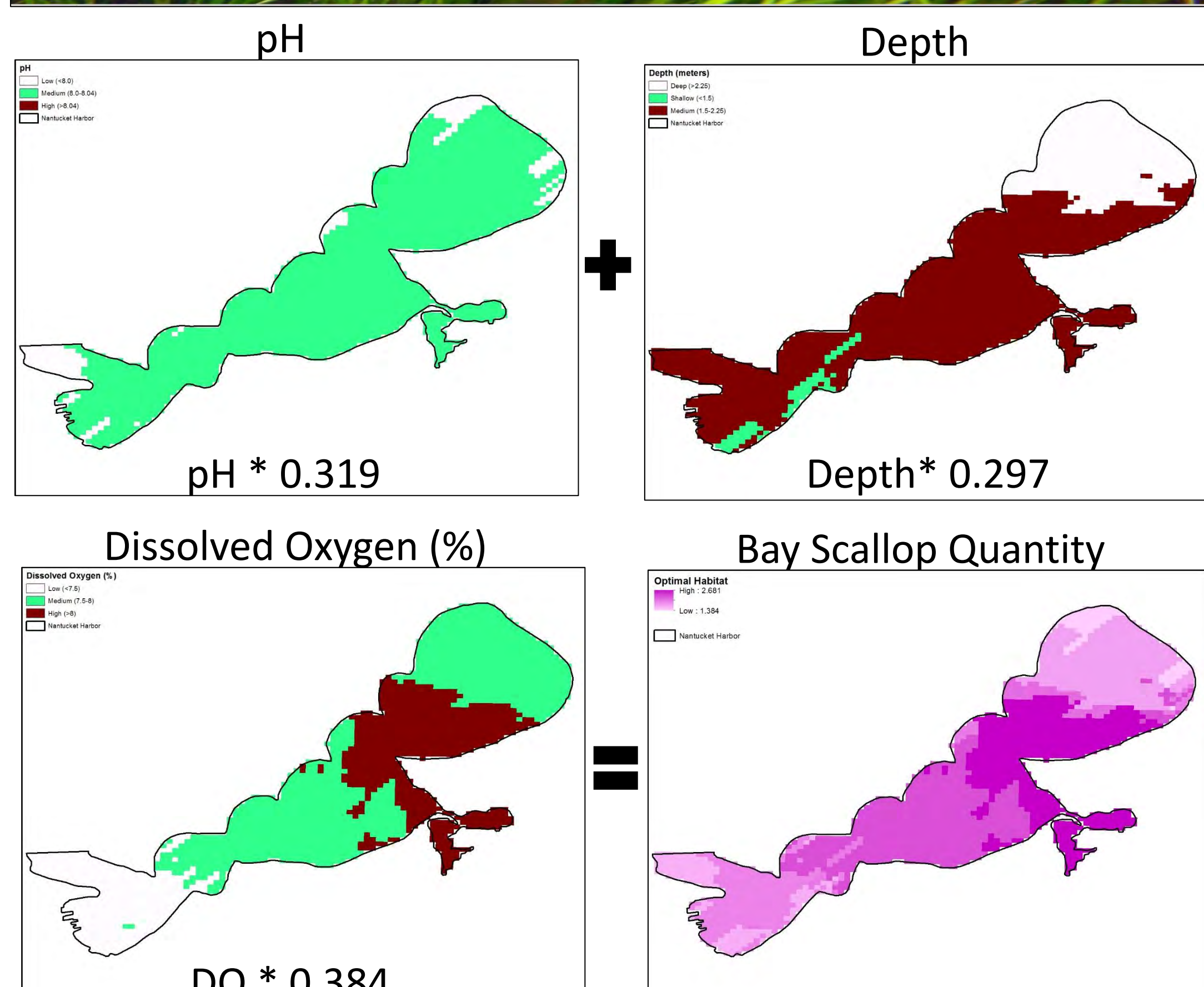
The location of best habitat is desirable because it is relatively undisturbed by anthropogenic activities, such as mooring fields or seasonal docks. Therefore, it is more feasible for this particular area to be targeted for conservation and management.

There are other explanatory variables that could potentially be incorporated into the model to further improve habitat prediction, such as nutrient levels, turbidity, and calm, protected areas.
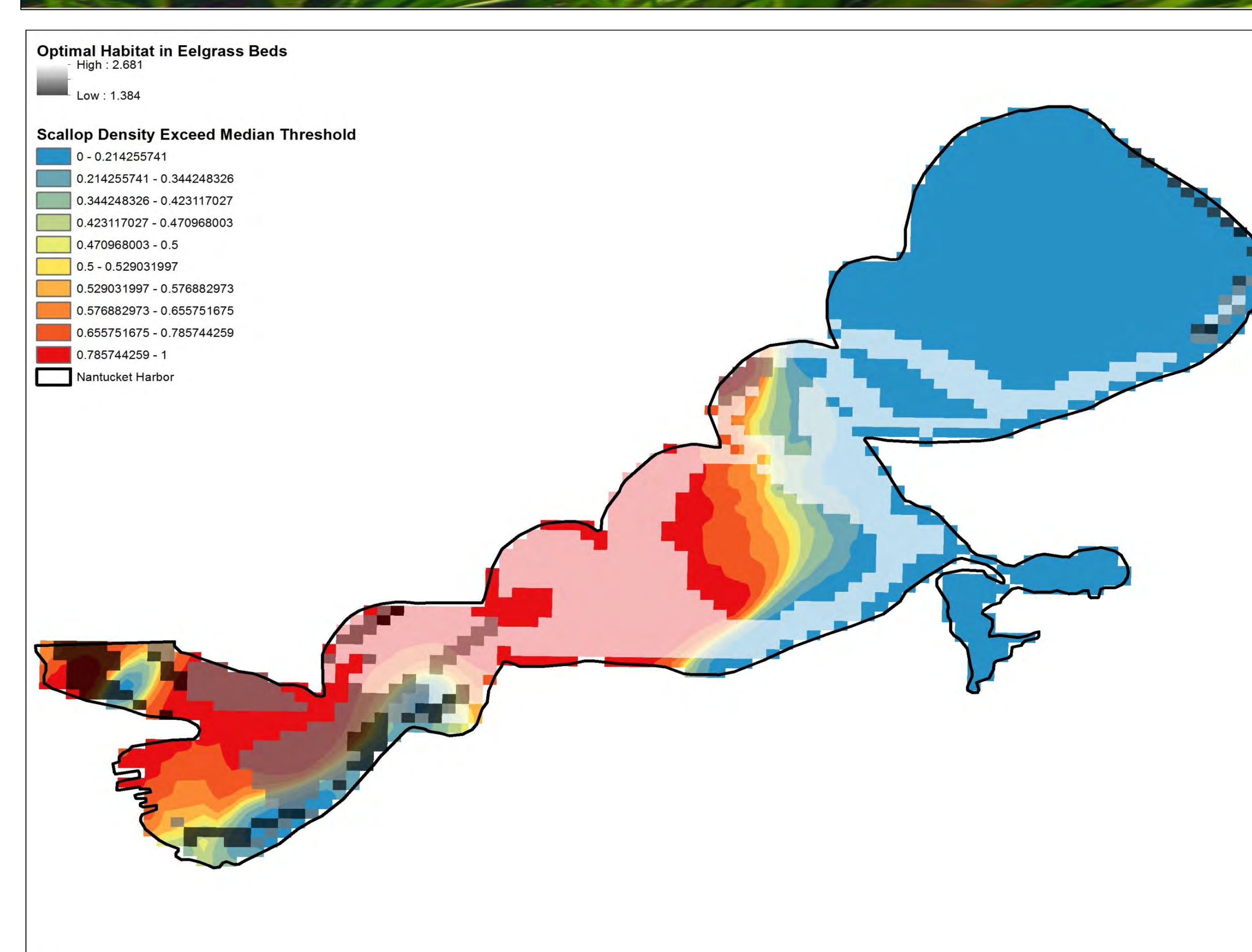
Implications for Management

- Can use abiotic variables as predictors for scallop habitat
  - Assess relative importance of abiotic variables
  - Informs regulation to maintain optimal scallop habitat
- Tracking population location and density trends with abiotic variables
- Aquaculture
  - Locations for seeding
  - Effective breeding augmentation
- Shows restriction based on eelgrass in high quality habitat
  - Indicates areas for potential eelgrass restoration

References

1. Nantucket Shellfish Association. 2014. Bay Scallops. <http://www.nantucketbayscallops.org/bay-scallops.html> Accessed March 10, 2015.
2. Peter Boyce, Maria Mitchell Association. Scallop Data. 2014.

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